



UNIVERSITI PUTRA MALAYSIA

WEB CAMERA APPLICATION FOR MOTION DETECTION

KOAY SU YEONG

FK 2003 61

WEB CAMERA APPLICATION FOR MOTION DETECTION

By

KOAY SU YEONG

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in
Fulfilment of the Requirements for the Degree of Master of Science**

April 2003



DEDICATION

To

My father :

Koay Chew Bin

My mother :

Teh Poh Gek

My sisters :

Koay Si Hui and Koay Si Wei

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

WEB CAMERA APPLICATION FOR MOTION DETECTION

By

KOAY SU YEONG

April 2003

Chairman : Hj. Abdul Rahman Ramli, Ph.D

Faculty : Engineering

Motion detection is the ability to recognize the presence of movements. There are many different ways to detect motion. The conventional way is by using either active sensor or passive sensor. The new method to detect motion is "vision motion detection". It is the artificial way of machine vision system compared to human's vision in detecting motion. Motion detection is the most important feature in digital video surveillance system. It gives the camera the capability to capture when needed rather than capture all the time and this leads to huge reduction in storage space. Alarm can also be triggered when unexpected motion is detected. This relieves the personnel in monitoring at all time.

This thesis presents the design and implementation of a low cost security system. The system consists of only a web camera and a personal computer, which is incorporated with motion detection capability. The motion detection capability is using the concept of "motion detection by vision". Therefore no hardware sensors like active sensor and passive sensor are required. The motion detection capability provided in this system is derived from image subtraction method.

This thesis project consists of three main stages, namely hardware setup, simulation and implementation. The first stage is setting up the system of which consists of PC and web camera. The web camera is only operable with the web camera driver installed in the PC. In the second stage, simulation done on the frame images using Matlab with Image Processing Toolbox as simulation tool to investigate the possibilities of motion detection algorithm on images captured by web camera. In the third stage, implementation process is done by coding the motion detection software using Microsoft Visual Basic 6.0. The algorithm that was successfully simulated is used as the reference for forming the working mechanism in creating motion detection software. This self-created motion detection software is then installed and run on the PC to function as a complete intelligent motion detection system.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia untuk memenuhi keperluan untuk ijazah Master Sains

APPLIKASI KAMERA WEB UNTUK PENGESANAN PERGERAKAN

Oleh

KOAY SU YEONG

April 2003

Pengerusi : Hj. Abdul Rahman Ramli, Ph.D

Fakulti : Kejuruteraan

Pengesanan pergerakan merupakan kebolehan untuk mengesan kehadiran pergerakan. Terdapat pelbagai cara yang berbeza untuk mengesan sesuatu pergerakan. Cara biasa ialah dengan menggunakan pengesan sama ada penderia jenis aktif atau penderia jenis pasif. Kaedah baru untuk mengesan gerakan ialah dengan "pengesanan pergerakan dengan penglihatan". Ia merupakan sistem penglihatan mesin secara buatan manusia berbanding dengan penglihatan manusia dalam pengesanan pergerakan. Pengesanan pergerakan merupakan ciri yang paling penting di dalam sistem pengawasan video digital. Ia memberi keupayaan kepada kamera untuk merekod ketika perlu membanding dengan merekod setiap masa dan mengurangkan banyak ruang penyimpanan. Penggera juga dapat dicetuskan ketika pergerakan tidak dijangka

dikesan. Ini mengurangkan beban kakitangan dalam kerja mengawas pada setiap masa.

Tesis ini menyampaikan rekabentuk dan pelaksanaan satu sistem keselamatan kos rendah. Sistem ini hanya terdiri daripada satu kamera web dan sebuah komputer peribadi, yang mempunyai daya keupayaan untuk mengesan pergerakan. Keupayaan pengesanan pergerakan ini menggunakan konsep "pergerakan pengesanan melalui penglihatan". Maka, tiada penderia aktif atau pengderia pasif yang diperlukan. Keupayaan pengesanan pergerakan yang terdapat di dalam sistem ini adalah diterbitkan daripada kaedah "penolakan imej".

Projek tesis ini terdiri daripada tiga peringkat utama, iaitu penyusunan perkakasan, simulasi dan pelaksanaan. Peringkat yang pertama ialah menyediakan perkakas yang mana terdiri daripada komputer dan kamera web. Kamera web hanya boleh berfungsi dengan pemacu kamera web yang dipasang dalam komputer. Pada peringkat kedua, simulasi imej daripada video dijalankan dengan menggunakan perisian Matlab dengan *Image Processing Toolbox* untuk menyiasat kemungkinan algoritma pengesanan pergerakan. Dalam peringkat ketiga, proses pelaksanaan dilakukan dengan pengekodan perisian pengesanan pergerakan dengan *Microsoft Visual Basic 6.0*. Algoritma yang berjaya dalam simulasi digunakan sebagai rujukan untuk membentuk mekanisme pelaksanaan dalam pengekodan perisian pengesanan pergerakan. Perisian ini kemudian dipasang dan berfungsi sebagai suatu sistem cerdas yang lengkap dengan keupayaan pengesanan pergerakan pada komputer.

ACKNOWLEDGMENTS

I wish to express my grateful thanks for the advice and assistance so generously given by my supervisor, Dr. Hj Abdul Rahman Ramli. This thesis project would not have been succeeded without his assistance. In particular, his leadership and support throughout the whole project. Also thanks to Dr. Veeraraghavan Prakash and Mrs. Roslizah Ali who are my co-supervisor. Thanks for their support and constructive critics for me to produce this thesis in a reasonable time. Their effort is highly appreciated.

Thanks to Beh Kok Siang, my senior in the research group for assisting me in the Visual Basic and making it possible to complete the prototype software. Also my course mate Lew Yuan Pok who always provides a great deal of valuable feedback on my research and this thesis. Also my senior in the research group senior, Qussay Abbas Salih al-Badri is always a source of smiles and providing his suggestions at the same time. My thanks to him for his great ideas for me in this thesis project also.

Not forgetting also, to all lecturers, staff and fellow course mates in Department of Computer and Communication System and Multimedia and Intelligent System Lab. All your encouragement throughout the duration of this thesis project has been invaluable.

Last but not least, I would also like to thank my parents and family members for all their supports. Without their unlimited support in many ways, I will not be able to complete this thesis.

I certify that the Examination Committee has met on April 2003 to conduct the final examination of Graduate Student on his Master of Sciences thesis entitled “Web Camera Application for Motion Detection” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Faculty of Engineering,
Universiti Putra Malaysia

Adznan Jantan, Ph.D.
Faculty of Engineering,
Universiti Putra Malaysia
(Chairman)

Hj. Abdul Rahman Ramli, Ph.D.
Faculty of Engineering,
Universiti Putra Malaysia
(Member)

Veeraraghavan Prakash, Ph.D.
Faculty of Engineering,
Universiti Putra Malaysia
(Member)

Roslizah Ali
Faculty of Engineering,
Universiti Putra Malaysia
(Member)



GULAM RUSUL RAHMAT ALI, Ph.D.
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date : 25 SEP 2003

The Thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfillment of the requirements for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Hj. Abdul Rahman Ramli, Ph.D.
Faculty of Engineering,
Universiti Putra Malaysia
(Chairman)

Veeraraghavan Prakash, Ph.D.
Faculty of Engineering,
Universiti Putra Malaysia
(Member)

Roslizah Ali
Faculty of Engineering,
Universiti Putra Malaysia
(Member)

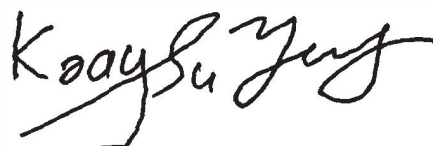


AINI IDERIS, Ph.D,
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date : **14** NOV 2003

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or con-currently submitted for any other degree at UPM or other tertiary institution.



KOAY SUYEONG @ GUO SI-YONG

Date : 26 SEP 2003

TABLE OF CONTENTS

DEDICATION	ii
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	vii
APPROVAL SHEETS	viii
DECLARATION FORM	x
LIST OF FIGURES	xiv
LIST OF TABLES	xvi
LIST OF ABBREVIATIONS	xvii

CHAPTER

I	INTRODUCTION	
1.1	Motion Detection	1
1.2	Web Camera	2
1.3	Background	3
1.4	Objective	4
1.5	Thesis Organization	6
II	MOTION DETECTION SYSTEMS REVIEW	
2.1	Overview	7
2.2	Motion Detection Sensor	9
2.3	Visual Motion Detection	10
2.4	Existing Visual Motion Detection System	13
2.5	Machine and Computer Vision	20
2.6	Video Surveillance	21
2.7	Web Camera	22
2.7.1	Web Camera Limitations	24
2.7.2	Web Camera Sensitivity	25
2.8	Comparison Between Three Cameras	26
2.9	Other Web Camera Applications	29
III	BACKGROUND THEORY	
3.1	Grayscale Image	30
3.2	Grayscale Histogram	30
3.2.1	Grayscale Histogram Comparison	31
3.2.2	Image Intensity Profile	32
3.2.3	Grayscale Histogram Equalization	33
3.3	Motion Data	36
3.4	Optical Flow	36
3.5	Change Detection	37
3.5.1	Image Subtraction	38



	3.5.2	Background Subtraction	39
	3.5.3	Temporal Subtraction	40
	3.5.4	Double Subtraction	41
3.6		Segmentation	42
	3.6.1	Thresholding	43
	3.6.2	Median Filtering	44
	3.6.3	Motion Based Segmentation	45
IV		METHODOLOGY	
	4.1	System Setup	47
	4.2	Software Simulation	49
	4.3	Grayscale Frame Images Extraction	49
	4.3.1	Video Clips Capture	50
	4.3.2	Frame Extraction	51
	4.3.3	RGB and Grayscale Image	53
	4.3.4	Grayscale Histogram Equalization	54
	4.3.5	Grayscale Image Profile	54
	4.4	Motion Detection Algorithm	55
	4.4.1	Background Subtraction	56
	4.4.2	Temporal Subtraction	57
	4.4.3	Noise Elimination	57
	4.4.4	Pixel Conversion	58
	4.4.5	Median Filtering	58
	4.4.6	Double Subtraction	59
	4.4.7	AND Operation	61
	4.4.8	OR Operation	63
	4.5	Motion Based Segmentation	65
	4.5.1	Block Operation	66
	4.5.2	White Pixel Replacement	66
	4.5.3	Background Subtraction Segmentation Method	67
	4.5.4	Background Subtraction with Block Operation Segmentation Method	68
	4.5.5	Double Subtraction with OR and Block Operation Method	69
	4.6	Motion Detection Software	70
	4.6.1	Motion Detection Software Working Flow	70
	4.6.2	Motion Detection Mechanism and Noise Removal	72
	4.6.3	Motion Sensitivity	73
	4.6.4	Graphic User Interface (GUI)	74
V		RESULT AND DISCUSSION	
	5.1	Video Capture and Frame Extraction	77
	5.2	Grayscale Intensity Histogram	80
	5.3	Grayscale Image Profile	83
	5.4	Grayscale Histogram Equalization	92

5.5	Image Subtraction	95
5.5.1	Background Subtraction	95
5.5.2	Temporal Subtraction	98
5.6	Thresholding	100
5.7	Median Filtering	107
5.8	Double Subtraction with AND Operation	110
5.9	Double Subtraction with OR Operation	111
5.10	Motion Based Segmentation	114
5.10.1	Segmentation Without Background	114
5.10.2	$n \times n$ Block Neighborhood	115
5.10.3	Segmentation With Background	119
5.10.4	Comparison Among the Three Methods	121
5.11	Motion Detection Software	123
5.11.1	Detecting Motion	124
5.11.2	Illumination Variation	125
5.11.3	Central Processing Unit Resources Utilization	126
5.11.4	Types of Motion	128
5.11.5	Detectable Distance	130
5.11.6	Recommended Settings for Software	131
5.11.7	Bottleneck and Limitation	132
VI	CONCLUSION	
6.1	Concluding Remarks	134
6.2	Advantages Offered	135
6.3	Recommendations	137
	REFERENCES	138
	APPENDICES	
	Appendix A : Publication	146
	Appendix B : Award and Achievements	147
	Appendix C : Matlab Source Code	148
	VITA	165

LIST OF FIGURES

Figure	Page
2.1 Webcam EC-300	23
3.1 Line segment indicated as red line on a grayscale image	33
3.2 Corresponding image profile graph	33
3.3 The classes and subclasses when using motion data	36
3.4 Flow chart of double subtraction	41
3.5 Grayscale thresholding	43
3.6 Median filtering using 3 x 3 neighborhood.	45
4.1 Flow chart of data acquisition flow in motion detection system	48
4.2 System setup	48
4.3 Video frames extraction flow chart	50
4.4 AVIedit version 2.9 opens an AVI as a series of frame images	53
4.5 Four image profile paths	55
4.6 Motion detection algorithms flow chart	56
4.7 Diagram of object location and motion region	60
4.8 Diagram of object location and motion region for AND double difference image	62
4.9 Flow chart of creating AND Double Difference Image	62
4.10 Diagram of object location and its motion region for OR double difference image	64
4.11 Flow chart of creating OR Double Difference Image	64
4.12 Motion based segmentation flow chart	65
4.13 Background Subtraction Method process flow chart	67
4.14 Background Subtraction with Block Operation process flow chart	68
4.15 Double Subtraction with OR and Block Operation Method process flow chart	69
4.16 Motion detection software working flow chart	71
5.1 Frame images Set I	78
5.2 Frame images Set II	79
5.3 Frame images Set III	80
5.4 Frame image with different color band and its histogram	82
5.5 Four image profile for Frame 1	84
5.6 Four image profile for Frame 2	85
5.7 Image profile comparison between Frame 1 and Frame 2	87
5.8 Image profile comparison between Frame 8 and Frame 9	88
5.9 Image profile comparison between Frame 1 and Frame 8	90
5.10 Simplified image profile graph for Frame 1 and path A	92
5.11 Low light scene equalization	93
5.12 Extreme low light scene equalization	94
5.13 Day scene equalization	94



5.14	Background subtraction for frame images set I	96
5.15	Background subtraction for frame images set II	97
5.16	Temporal Subtraction for frame images set I	98
5.17	Temporal Subtraction for frame images set II	99
5.18	Background subtracted image for Set I of Frame 6 with different thresholding percentage	101
5.19	Background subtracted image for Set II of Frame 9 with different thresholding percentage	102
5.20	Temporal subtraction frame images Set I between frame 6 and frame 5 with different thresholding percentage	103
5.21	Temporal subtraction frame images Set II between frame 9 and frame 8 with different thresholding percentage	104
5.22	Graph of number of white color pixel in input frame image Set I after thresholding for both type of subtraction	106
5.23	Graph of number of white color pixel in input frame image Set II after thresholding for both type of subtraction	106
5.24	Median filtering with 3 by 3 neighborhood for background subtraction	108
5.25	Median filtering with 3 by 3 neighborhood for temporal subtraction	109
5.26	AND background double difference image	110
5.27	AND temporal double difference image	111
5.28	OR background double difference image	112
5.29	OR temporal double difference image	113
5.30	Background subtraction segmentation method	115
5.31	Number of white pixel in input frame image Set III before and after block operation	117
5.32	20 x 20 neighborhood	118
5.33	Background subtraction with block operation segmentation method	120
5.34	Double subtraction with OR and block operation segmentation method	121
5.35	Motion detection software screen shot	124
5.36	Three types of motion	129

LIST OF TABLES

Table	Page
2.1 Specifications of Webcam EC-300	23
2.2 Advantages of digital camcorder, digital camera and web camera	27
4.1 Relationship between thresholding percentage and changes in pixel value	58
4.2 Truth table for AND operation	61
4.3 Truth table for OR operation	63
5.1 Number of white pixel with different thresholding percentage for background subtraction on input frame image Set I	101
5.2 Number of white pixel with different thresholding percentage for background subtraction on input frame image Set II	102
5.3 Number of white pixel with different thresholding percentage for temporal subtraction on input frame image Set I	103
5.4 Number of white pixel with different thresholding percentage for temporal subtraction on input frame image Set II	104
5.5 Average number of white pixel after different thresholding percentage	105
5.6 Number of white color pixel after median filtering for background subtraction	108
5.7 Number of white color pixel after median filtering for temporal subtraction	109
5.8 Number of white pixel of input frames images Set III after block operation	116
5.9 Average value of motion percentage with illumination variation	126
5.10 CPU resources utilization rate under different situation	127
5.11 Three types of motion and its corresponding motion percentage	129
5.12 Difference of current motion percentage and noise with different distance	130
5.13 Summary of recommended settings for motion detection software	132



LIST OF ABBREVIATIONS

2 D	: Two Dimension
3 D	: Three Dimension
AVI	: Audio Video Interleave
BMP	: Bitmap image
fps	: Frame per second
GIF	: Graphics Interchange Format
JPG or JPEG	: Joint Photographic Experts Group
PC	: Personal Computer
RGB	: Red, Green, Blue
TGA	: Targa Graphics Adaptor
USB	: Universal Serial Bus

CHAPTER I

INTRODUCTION

1.1 Motion Detection

Motion detection includes detecting and recording the whole movement process. The purpose of motion detection is to provide an automatic detection in the region of interest. The task for motion detection is to detect motion in a region of interest. This region is always embodied in a region of awareness or in terms of the camera geometry is called the field of view. It is also defined as a portion of environment being monitored. The region of interest in the present case is the environment with moving object and activity. A region of interest can be therefore a person, an animal or an artifact, circumscribed with the term moving object. For simplicity and generality, recognition based detection is not assumed. An appropriate algorithm does the detection of moving object.

1.2 Web Camera

Web camera or more precisely should be named as PC camera. It is the type of computer-based camera that can only function when it is connected to PC. It is more commonly being known as webcam. This is a small and compact type of digital video camera. Most of the web cameras currently in market are using standard Universal Serial Bus (USB) but the old type was using PCI computer connections.

Web camera has a wide variety of usage in many different fields. It was used in astronomical observation and photography, animal observation, robotic webcam (Web Cam World 2001), recreation of 3D modeling (3D Webcam 2003), weather observation in Alaska (Alaska Climate 2003) and many others. Generally, its usage can be classified according to its function and place where the web camera is installed, e.g. scenery cam, personal cam, weather cam, building cam, etc. For different usage objectives and purposes, different supporting hardware and software may be required (Churchill 2001). New application of web camera is developed every now and then. The new applications of web camera require software or both hardware and software to achieve the desired function.

1.3 Background

Video surveillance and security systems have become very common in modern days. This kind of system can easily be found in places like retail stores, banks, supermarkets, airports, commercial buildings and even private premises. There are two kinds of video surveillance and security systems: analogue system and digital system. In traditional systems for security operations, cameras are used to deliver analogue video images to monitors or time-lapse videocassette recorder (VCR). Although many local image processing functions are possible to improve the system application, this requires a lot of processing resources and high-power-consuming hardware. Although digital video surveillance and security system is widely used, analogue system still serves as a cheaper alternative. Charge coupled devices (CCD) camera and digital camera one among the most popular cameras used in the system.

Digital surveillance systems are mostly specifically designed for commercial use and it has always been out of reach for other users. The cost for CCD cameras, networking devices and the software designed for this system has made it inaccessible and unpractical for home users with moderate requirements. Also, not all the existing product has the motion detection function.

Most of the video surveillance and security systems in the market does not issue alarms in real time, manual monitoring system are costly in term of manpower.

This can be overcome by a real time motion detection system with the ability to automatically analyze the video images and archive the images with moving objects.

Similar products are available in market but the price is expensive. The price of similar software can range from RM 120 to RM 200 excluding the camera. Certain motion detection is bundled with the whole security system. The security system is customized for any security purpose and the cost for the system may range from RM 20,000.

1.4 Objective

The main objectives of this thesis project are as stated in the following:

- i. To investigate if motion detection is possible for web camera.
- ii. To develop a low cost security system using web camera.
- iii. To develop software with motion detection function algorithm.

This project aims to achieve web camera application system with automatic motion detection capability. The main idea is to develop a low cost surveillance system using web camera, which runs the software that is incorporated with motion detection algorithm. It uses the concept of "motion detection by vision" to achieve motion detection capability where no hardware sensors are required. The

automatic motion detection capability helps to reduce archive space and monitoring manpower. The system would be a simple "do-it-yourself" system, which means anyone can just setup by himself/herself.

In this project web camera is chosen as it is low cost captured to other capture devices. It is used as video capture device for the motion detection in surveillance purpose. Only a web camera and a PC required for this purpose and therefore it is cheap instead of sophisticated surveillance system that involves Charge Coupled Devices (CCD) camera or digital camera.

Compared with a conventional camera, images taken with a web camera have lower resolution due to the mapping of large field of view to the small camera lens in web camera and its sensor limitations. The image has generally non-uniform resolution and the resolution cannot be better than the cameras with standard imagers and is often inferior for most parts in an image due to bigger pixel size (Esensual Studios 2001). Hence, in this project investigation need to be done to check if motion detection is possible with such a low-resolution images by simple simulations.

The flaws of existing surveillance and security system would be overcome by a real time motion detection system with the ability to automatically analyze the video images and archive the images with moving objects. Therefore, a digital surveillance system based on web camera and targeted for small-scale user is developed.

1.5 Thesis Organization

This thesis is organized in six chapters. Chapter I is the introduction of this thesis project and states the objectives of this thesis project. Chapter II provides the literature review of motion detection systems. Technical specifications of EC-300 webcam used in this thesis project and its explanation are also included. This chapter also reviews the existing motion estimation systems. The background theories of all the methodology used to achieve motion detection is explained in Chapter III. In Chapter IV, the methodology of setting up a low cost motion detection system is discussed and followed by software implementation on web camera. Simulations for images captured by web camera are done using MATLAB with Image Processing Toolbox. In Chapter V, all the results and discussions from simulation are presented. The results also include motion detection software compiled using Visual Basic 6.0. In the last chapter, Chapter VI is the conclusion for this thesis project. Some recommendations for the future work are included as well.

CHAPTER II

MOTION DETECTION SYSTEMS REVIEW

2.1 Overview

According to biological study in vision system, all biological vision systems are always evolving to cope with the changing world. The same thing applies to machine vision system, which also developed in the same way. For a computer vision system, the function and its applications are becoming more and more complicated. The requirement for the system to have the ability to cope with moving and changing objects, changing illumination and changing viewpoint is essential to perform several tasks (Shapiro and Stockman 2001).

Motion imaging is an interesting and challenging topic starting from the middle of 50's. During 60's and 70's, static scene analysis received a lot of attention. In the 80's dynamic scene was becoming a popular topic in the research. The development is followed by the development of camera devices. In the 70's camera was becoming more and more popular whereas in the 80's video was blooming up and the requirement for dynamic scene was increased. Although in the early years, computer vision systems were concerned primarily with static scenes, computer vision